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Interaction Patterns for Smart Spaces: A Confident Interaction Design Solution for Pervasive Sensitive IoT Services

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Abstract—Smart spaces represent a powerful tool for deploying the new pervasive sensitive services based on Internet of Things products and developed in current Information Society close to users. Researchers have focused their efforts on new techniques to improve systems and products in this area but neglecting the human factors related to psychological aspects of the user and their psycho-social relationship with the deployment space where they live. This research proposes to take into account these cognitive features in early stages of the design of smart spaces by defining a set of interaction patterns. By using this set of interaction patterns it is possible to influence over the confidence that users can develop during the use of IoT products and services based on them. An evaluative verification has been carried out to assess how this design engineering approach provide a real impact on the generation of confidence in the users of this kind of technology.

Index Terms— Confidence, Interaction Design, Interaction Pattern, IoT, Smart Spaces

I. INTRODUCTION

MARKET movement and business investment from the largest companies in the Information and Communication Technologies (ICT) arena offer an interesting perspective about how services and products in the Information Society (IS) have evolved over the years [1]. The evolution of investments by the representative ICT and IS companies shows a design and development trend towards sensitive services and products with both a

greater social impact in terms of quality of life and a wide margin of economic and social benefits [2], [3].

The emerging pervasive technologies such as Internet of Things (IoT) are giving shape to the services with a greater degree of accessibility, autonomy, ubiquity, delocalization, and control [4], [5]. Therefore, it is currently possible to develop new and more accessible pervasive sensitive services or products for users independently of their location or time [6], [7]. These new pervasive sensitive developments manage data that is not only based on the physical disposition of the user in regards to the environment (such as geographical position, interior positioning, or patterns of movement) but also related to more personal aspects of their physical state, psyche, or behavior patterns [8]. Thus, the success of these new developments will be determined by a proper deployment close to users, being able to interact with them in their daily life [5], [9]–[11].

Despite the potential benefits offered by the aforementioned developments, the complete acceptance by the final users is not guaranteed [12]. The ability of the IoT technologies to integrate computing everywhere, make them an ideal candidate for the implementation of smart spaces (SSs), and thus, this pervasive technology can transform living spaces in SSs [13]. Through the application of IoT technologies, SSs will be able to recognize and interpret the human interaction with the real environment. However, the very nature of IoT technologies can generate feelings of incomprehension and intrusiveness in the humans. These feelings worsen the acceptance of the technologies by the users. So far, researchers have

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focused their efforts on new techniques and technologies to improve the privacy and security of these kind of developments [7], [14], [15] and other low-level issues [16]–[18]. In relation to aspects related to human factors and psychological aspects of users there is also extensive documentation that explains the inclusion of interaction design, user experience and human-computer interaction in the process of developing solutions in the context of ubicomp, pervasive technology, intelligent spaces and environmental intelligence [19]–[21]. However, these studies and initiatives approach the design of the final solutions from a traditional point of view, based on user-centered methods, forgetting the recommendations made by important authors such as Tennenhouse or Norman [22], [23]. These authors explain that traditional approaches to design (and by extension, development) are not intrinsically valid for contexts of invisible or ubiquitous computing. Here, users play a different role (supervisory activity) [23] and benefit from the result, but without actively intervening in the computational process. In this way, traditional user requirements must be replaced by activity requirements, giving more importance to what the user wants to do, leaving the technology in the background and forcing it to adapt to the activity or needs of the user. Therefore, it is not a matter of explaining or helping to understand the underlying technology of a pervasive sensitive service, but to ensure user acceptance of this kind of service when highly sophisticated technology is introduced into a highly private space (such as a home), which is necessary for its final development.

Following this idea, the relationship between users and SSs represents a key factor in promoting final acceptance of new pervasive sensitive developments [9]. Thus, the aim of this paper is to define a group of interaction patterns as a design tool for modelling the relationship between users and the SSs where the pervasive sensitive developments are deployed. These interaction patterns try to promote a psychological state of confidence in the users by increasing the understanding and control [12] of the users on the activities which compose a sensitive pervasive service deployed in the SS, guaranteeing the new

role of supervision for users.

Interaction patterns offer an opportunity to keep users' needs and expectations in the first design stages at the same time that allow unification of concepts originating from different areas of study such as human factors, engineering and interaction design, in order to guarantee an optimal level of acceptance. Specifically, this group of interaction patterns provides a design guide for all stakeholders involved in the definition of pervasive sensitive development based on IoT and SSs, i.e. daily life environments where these developments have to be deployed. Thus, this set of design patterns includes what questions the design should answer, its limits and the principles that will be used for the implementation stage.

To address the objective of this paper, we first present an overview of previous research efforts oriented to design and transform intimate and personal spaces into SSs by including IoT services and products and how different design techniques and methods have been used with this purpose (Section 2). Then, we describe the principles and definition of the set of interaction patterns (Section 3) and the assessment of the ability of the patterns proposed to build confidence in users of a SS and therefore fostering the final acceptance of pervasive sensitive developments deployed into them (Section 4). Finally, we summarize the discussion of major findings provided by this research (Section 5) and the conclusions of this work (Section 6).

Finally, the authors of this research point out that part of the work presented in this manuscript has been done and reported in the PhD dissertation authored by the first author [24], completing it with later investigations.

II. BACKGROUND

An interaction can be defined as *a mutual or reciprocal action or influence exerted between two or more objects, people, agents, forces, functions, etc.* [25], [26]. According to the scope of this research, the term refers to the design of the behavior of products, objects and systems with which the user interacts (Interaction Design) and the study of the communication relationship between these entities (Human Computer Interaction) [27].

The study of interactions allows designers and developers to enhance people's understanding of what can be done with some element and therefore increasing the final adoption of that by users [12].

Interactions can be classified into the following four groups [27]:

1) *Instruction interactions*

These kind of interactions describe how users carry out a task by telling the environment how it should work. As such, an instruction represents a concrete action on the environment generated by the user. The environment processes said action, providing the resident user with the result in the form of feedback adapted to his/her needs. Examples of instruction interactions are turning a device on or off, activating or deactivating a service, using an object in the environment, being involved in events in the environment. In this way, this type of interaction represents a simple and direct interaction that provides the resident user with control over the general behavior of the environment.

2) *Conversation interactions*

A conversation represents a dialogue between two entities with a specific objective. Conversation interactions are based on the idea that an individual can converse with an environment in the same way that he or she could establish a dialogue with another person. As opposed to an instruction interaction, conversations involve a communication model in two directions, user to environment and environment to user. This type of interaction is useful in the development of comprehensible interactions, since they allow the user to clarify any concerns that an activity might generate. In addition, designed elements such as SSs can use these interactions as a mechanism to personalize the services it holds. In general, conversation interactions are used so that an entity may obtain information from another entity, for example with the goal of supervising an activity or state, or to adapt an action to the needs or preferences of the entities involved.

3) *Manipulation interactions*

These kinds of interactions represent a type of action-reaction interaction where interactive elements processes said action in order to generate a

result based on the user needs and expectations, and obtaining certain feedback. In addition, the elements involved in a manipulation interaction offer the user a choice in how they are used (affordance). Some authors have used these kinds of interactions as the basis for defining and building SSs [9], [28]. In this way, the environment can use said objects to interact with users intuitively, that is, by encapsulating complex actions from the services offered into direct interactions with everyday objects that the users comprehend and accept. Thus, the objects in the environment are used to the extent of their capacities as interfaces that use the user's experience with them to improve the interaction between the resident user and the environment.

4) *Interactions of exploration*

This mode of interaction is related to the way in which the user behaves within a space and interacts with the elements placed in it. The space can analyze the activities its users perform within it with the goal of adapting its behavior and assisting with their performance. In case of SSs, there is no direct interaction between the user and the environment unless the environment is aware of the user's current context via sensitization of his or her activities.

In the other hand we find the design patterns. The concept of design pattern was introduced by C. Alexander in [29] as re-usable form of a solution to a design problem that provides a common terminology for discussing the situations designers are faced with in the form of language, that is a pattern language. This idea has been adapted for various other disciplines, including teaching, development organization or computer science [30], [31] and interaction design [32]. In the context of this research, design patterns together with the concept of interaction provide us a useful way to describe solutions to common usability or accessibility problems in a specific context [32], [33]. This design tool allows researchers and designers to document relationship models that make it easier for users to understand an interface and accomplish their tasks [30].

Commonly, interaction design patterns have been used in the field of web and mobile applications development [33]–[35]. This is because the usability of the system lies almost entirely in the

graphical user interface (GUI) [36] and also, the GUI is used as an understandable approach of the underlying data model [34].

The success of this design approach has favored its inclusion in the new scenario of interaction proposed by ubiquitous computing and pervasive technology, where understanding and user control over the system becomes extremely important to ensure final acceptance. As pointed out by M. Weiser in [5], ubiquitous computing offers a new approach based on the calm, tranquility and confidence, making the user feel at home, thus allowing them to carry out their daily activities in a normal, intuitive fashion, while at the same time benefitting from the functionality of these shared components, in a serene and controlled manner. In case of SSs, they represent homogeneous platforms and custom for the interaction between its inhabitants and the ubiquitous services that they are deployed. Callaghan define them as "...spaces where the actions undertaken by many interconnected controllers are organized by proactive services in such a way that is possible to offer comprehensive interactive functionality to improve the experience of their occupants" [9]. Thus, SSs provide a custom interface through the use of the space's own devices, such as household appliances, furniture, clothing, etc., that are widely accepted by users because they are part of their own living spaces [37].

However, a systematic related literature review shows that the efforts of researchers in this field have been focused on more technical aspects and applicability, such as the development of sensors and actuators [38]–[41], privacy and security [42], [43], [16], [44], interoperability [45], [46], safe energy [47], [48], or how to design and develop ubicomp products and services [49], [50]. In case of ubiquitous computing, in [51] the authors analyze how much researchers have tried to apply design patterns to this computational paradigm. There, researchers use design patterns to help developers deal with complicated aspects of ubiquitous computing as intelligence, device discovery and association or context-awareness.

These examples provide insights design about key aspects in the development of SSs. But these are

oriented to creators of this technology, leaving aside qualities related to end users such as cognitive features, interactivity, and finally, user acceptance. In this sense, research works like those by [9], [10], [52], [53] pointed out the need of an user-centric view of the conception and development of SSs in order to ensure their final adoption by users. The user acceptance of SSs, as Kaasinen remarks in [53], depends not only on technical aspects but also on the social, cultural and cognitive context of user. Providing design tools such as interaction patterns, to include these features in early stages of the development of SSs can help to shape their vision into acceptable and pleasing pervasive sensitive service interfaces for all those who live and act in them.

III. THE SET OF UNDERSTANDABLE INTERACTION PATTERNS FOR CONFIDENT SSs

As we have introduced in Section 2, authors in [27] define all of the interactions that users can carry out with any interactive elements, classifying them in four basic groups: instruction, conversation, manipulation and exploration. To define the set of interaction patterns proposed in this research we have followed the model proposed by Duyne et al. in [54] and the pattern structure proposed by Gamma et al. in [55], [56]. These directives establish a group of questions that should be answered by each pattern in order to correctly define it and the most common template used to uniformly express the content of each pattern.

The questions that must be answered by each pattern:

- 1) *What problem do they resolve?*
- 2) *When is a known solution needed?*
- 3) *Why is it necessary?*
- 4) *How is it applied?*

The final template followed to represent each pattern is composed by the following sections:

- 1) *Pattern's name: a descriptive and unique name to the pattern;*
- 2) *Problem or intent: a description of the problem to be solved by the pattern and therefore the goal behind;*

- 3) *Solution: a description of the solution offered by the pattern to the problem stated;*
- 4) *Motivation and applicability (Use when...): a context in which this pattern can be used;*
- 5) *Implementation (How...): a description of the solution part of the pattern;*
- 6) *Need of the pattern and consequences (Why...): Needs arising and extracted of the problem to be solved and the consequences of applying it;*
- 7) *Related patterns involved in the implementation of the pattern proposed if there are any.*

Below we describe the patterns resulting from our research.

B. Defining the Set of Problems

As it has been pointed out, a pattern must to provide a design solution to a specific problem. The set of problems to be solved was defined by performing a focus group with 10 experts (N=10) in different fields of design such as product design, pervasive services and user experience design, sociology and psychology. In addition, this performance used the author's previous knowledge in ubicomp and services described in [57], [58] to set up the analysis scenarios. By using an Qualitative Data Analysis (QDA) tool the transcript of the focus group was analyzed in order to extract the main concepts pointed out by experts. These concepts were grouped in five main insights, which represent the set of problems.

Following, the set of problems and concepts related to each are listed:

PR1 – Users need to know if the intelligent environment can implement a given pervasive service and if they have been identified correctly.

C1) I use the service where and when I decide;

C2) The service works only with me (my daughter) and is not affected by other people interfering in its operation;

C3) If I do not want to use the service, it is not activated/not running;

C4) The service tells me and justifies the reasons why it does not work. In addition, I know that the service is not running at all times.

PR2 – Users need to have a record of the information collected by the smart environment, where the information is encrypted and stored or

deleted as the user chooses.

C5) I can use the service wherever I want/can because when I stop using it all data and information captured is deleted;

C6) The data generated are protected both by regulations/laws and computer security techniques;

C7) No one has access to the information obtained by the service;

C8) The service stops working when I decide, without objections;

C9) Once stopped, the service confirms that it has stopped working.

PR3 – The points of interaction between the service and the user are transparently immersed in the environment through the use of everyday objects that have been augmented with computational capabilities.

C10) The use of service favors my development and I can see the improvements that I have been promised;

C11) I don't need anyone to explain how the objects in the environment work and can I use them normally;

C12) I fully recognize the objects used by the service: toys, electrical appliances, Smartphone, tablets, etc.;

C13) The objects used by the service do not produce shame/embarrassment because they are familiar and the rest of the people in my environment also have/use them.

PR4 – In general, SSs need to gather more information about users than what the pervasive service initially provides and therefore SSs should initiate a conversation with users. However, this process may generate suspicion or rejection from users if not developed transparently.

C14) Due to the fact that I am somewhere different than where I usually use the service, I understand that the service will ask about how to perform specific actions;

C15) Only I receive the questions, and nobody else is part of the dialogue;

C16) I can communicate with the environment when I want and it answers me;

PR5 – The pervasive service typically uses analysis of the actions and activities that a user

performs in a smart environment to adapt and improve. The environment, through sensors, collects this type of information and adapts its behavior to assist the user in achieving the goal set out by the service. In this process, there is no direct User-Environment/Service interaction, since the monitoring/sensing process is usually transparent to the user.

C17) The activities that I carry out in a space are not communicated to anyone outside the service;

C18) Only the service and I know what activities are analyzed;

C19) My daily activity does not interfere with the service. I can perform other actions without generating errors and also, if I decide to carry out an activity in a different way, the service behaves correctly.

C. Set of Interaction Patterns

Once the set of problems to be solved was enough mature the set of interaction patterns was developed. Following sections present these problems and their solutions in form of interactions patterns, following the template presented before.

1) Greeting Pattern

The problem solved by the pattern is the one previously defined as PR1.

- a) Solution: The SS should inform its users if a pervasive service can be deployed in the environment and if that is not possible, the SS should indicate the reason for its impossibility;
- b) Use when: Users come to an SS and are syndicated to a pervasive service;
- c) How? The pervasive service starts the conversation with the SS. Then, the pervasive services report the activity associated with it to the SS, and as such, the actions that the SS should handle. As such, the SS knows what context it should create or what resources it lacks for adequate deployment. Once the SS determines the possibility of deployment, it reports the final decision to the service. If deployment is impossible, the SS informs the pervasive service that it lacks the necessary resources for proper functioning. Lastly, the pervasive service provides the appropriate feedback to users. This communication must be secure and private;
- d) Why? Users of pervasive services want to use them as much as possible. However, they must decide (control) when to start the service. Likewise, in the event that the SS cannot deploy the service, the user needs to know the reason (understanding);
- e) Other patterns involved: Depending on the devices

used to develop and deploy personalized services, it may be possible to use other patterns of personalization commonly used in web environments, such as sign-in, registration, or personalized windows.

2) Farewell Pattern

The problem solved by the pattern is the one previously defined as PR2.

- a) Solution: The SS should ask users if they want to store or delete the information related to the pervasive service that was collected by the SS. Whatever the response is, the SS should inform the user of stored or deleted data and the state of the process;
- b) Use when: Users stop using pervasive services or leave the SS;
- c) How? The pervasive service determines if the process is finalized, and as such, initiates the farewell process with the SS. If the users leave the environment, it is the SS that should begin the farewell process. In the first example, the pervasive service informs the SS that it has finalized and the SS should gather all of the related information in order to delete or store it, depending on the user's decision. In the event that the user leaves the environment, SS should ask the pervasive service what to do with the related information. In both cases, the SS should generate a summary of all of the activities involving the pervasive service and the information gathered. Lastly, the pervasive service provides the appropriate feedback to users. This communication must be secure and private;
- d) Why? A farewell pattern offers users of pervasive services control over information gathering by independent entities. Sometimes, these pervasive services may handle sensitive data and, as such, appropriate storage or full deletion is necessary to assure final user acceptance. Thus, encapsulating this process in a farewell pattern helps users to understand that the process has finished securely and privately;
- e) Other patterns involved: Depending on the devices used to develop and deploy personalized services, it may be possible to use other patterns of personalization commonly used in web environments, such as log out.

3) Action-Reaction Pattern

The problem solved by the pattern is the one previously defined as PR3.

- a) Solution: When an action performed by the user affects a pervasive service, the SS must provide feedback to the user through the pervasive service related to the action. Otherwise, the action does not provide feedback to the user;
- b) Use when: The user performs an action in the SS or manipulates an intelligent everyday object;
- c) How? Performing actions or manipulating intelligent objects in an SS means an action-reaction-type interaction, where the environment processes the

action in order to generate a reaction based on the terms specified in the pervasive service. To this end, the user performs an action on an object with the purpose of obtaining concrete feedback. The object establishes a communication process that the intelligent space must analyze, with the goal of producing a result in accordance with user expectations. This process may imply an update of the pervasive service. Lastly, the object or environment will communicate the result of its action to its users. The objects involved in a manipulation interaction offer the user an idea of how they are used (affordance). As such, the SS may use these objects to interact intuitively with the users. This is achieved by encapsulating the complex actions associated with the services offered in interaction with the everyday objects understood and accepted by users. In this sense, objects in the environment are used, extending their capacities to create confident interfaces in order to improve interaction between the user and the SS via analysis of the user experience.;

- d) *Why?* This model is based on Activity Theory, which determined that all activities performed by users are broken down into actions and tasks [59]. As such, the use of actions and tasks as design elements provides a new way to model SS from a point of view that is similar to human behavior. This allows a better general understanding of interaction to be generated in the SS. Thus, it is possible to increase not only the calculation capacities of the intelligent environment and its objects, but also simulate the habitual physical behavior of those elements when an action implies a reaction, which is communicated to the user.;

4) Conversation Pattern

The problem solved by the pattern is the one previously defined as PR4.

- a) *Solution:* The conversation process should end with feedback to the users so they can verify that the information has been supervised and updated. All questions and answers corresponding to the dialogue between the user and the SS will be reflected in an accessible and verifiable document (such as the Contract-Document);
- b) *Use when:* The SS needs to complete all information from the users that participate in the service with the purpose of adapting itself to the objective defined by the related pervasive service;
- c) *How?* The SS should provide the appropriate feedback to the user involved in the conversation, with the purpose of providing all of the information necessary to guarantee process supervision. As such, each question generated by the environment implies processing of the information obtained from the answer and final feedback to the user. The whole process must be recorded so the process information is accessible to users at any time;

- d) *Why?* Users cannot make direct decisions about the IE's internal computing process and the services deployed within. However, this pattern offers a control method to supervise the functioning of the environment through a direct conversation with the SS, maintaining the computing capacities it offers;
- e) *Other patterns involved:* Depending on the devices used to develop and deploy personalized services, it may be possible to use other patterns of personalization commonly used in web environments, such as customizable windows of feedback or visualization patterns.

5) Exploration Pattern

The problem solved by the pattern is the one previously defined as PR5.

- a) *Solution:* All handling of the information collected by the SS sensors should be reported to users via the appropriate feedback;
- b) *Use when:* Any sensor processes information related to activities performed by users;
- c) *How?* When the SS finishes the user information detection process, it provides appropriate feedback to the users with the group of activities analyzed. Via appropriate feedback showing a summary of the user activities analyzed by the SS, supervision of how the SS backs up the deployed pervasive services is permitted;
- d) *Why?* Supervising the invisible behavior of the SS sensors, using appropriate feedback, increases user's confidence in User-Environment interaction;
- e) *Other patterns involved:* In some cases, it may be useful to combine this interaction pattern with the action-reaction model in order to break down the actions involved in exploration activities.

IV. VERIFICATION OF THE INTERACTION PATTERNS

Finally, a verification process was developed in order to assess how these interaction patterns fit with the research objectives and provide a valid solution to the problems previously posed.

The pilot study performed in this section considers the impact of the proposed interaction patterns over the user acceptance of a pervasive sensitive service based on IoT and deployed in an SS. For this verification we have used the pervasive technology and its pervasive sensitive services related exposed in [58] and [57]. In this case, the pervasive sensitive service is aimed at studying and

monitoring the psycho-motor development of children, and therefore, it must accompany the users in their daily lives and be involved in their daily activities. Usually this kind of developmental control process is carried out in specialized therapy, schools or health centers through specialist supervision. The inclusion of IoT products for monitoring development enables the supervision when specialists are not present to generate information about the behavior of users during their daily activities, for example, in the case of children this will be during play activities at home.

There are several possibilities to be analyzed in this verification process but we select one which cover to important requisites: first it is a service that uses IoT technology and also uses the user environment as deployment platform; and second, the service offered is a pervasive sensitive service, which we consider more restrictive than other, that is, services that provide a specific diagnosis when faced with specific events. In the context of children, these services must be transparent and imperceptible in order to not affect the monitored activity. However, parents or legal guardians of these users should be aware of their deployment and use and therefore, accept such developments. We consider that once covered the needs of this kind of pervasive services could be possible to address, in general, other kind of minor restrictive services.

Therefore, the set of patterns proposed in the previous section aims to promote the acceptance of final users by generating optimum confidence states. The pilot study presented below aims to assess the merit and value of this set of patterns in relation to the level of confidence generated in the supervising users, i.e. the parents.

A. Verification Method

For this pilot study an evaluative investigation based on focus groups has been designed for a group of Spanish parents (N=10) of children aged between 0 and 6 at Cardenal Cisneros' Psychology Campus. This group of subjects was selected because the context of the IoT and service under evaluation.

For its part, the evaluative investigation represents a qualitative tool suitable for assessing how a policy of action has an impact on an object of

study. In this case, the policy of action is represented by the defined set of interaction patterns and the object of study is defined as the generation of confidence in the parents and therefore, the final acceptance of the solution. Which is to say, through this study, the aim was to assess the capacity of the patterns of interaction to generate Understanding and Control in an intuitive way in parents at the time of use of a pervasive sensitive service for monitoring their children at home (as a case of SS).

B. Evaluation of Confidence Interaction Patterns

The first phase of the study was focused on the extraction of the concepts under analysis based on the problems that each pattern of interaction seeks to solve. These concepts were associated to variables related to the definitions of the terms of confidence and pervasive sensitive service [12]. This operationalization is presented in the Table 1. Lastly, statements were generated, in the form of cards, which were to be presented to the subjects of the study. The aim of these cards was to abstract the user from technicalities of the concepts analyzed through colloquial language that would give rise to a group discussion.

C. Development of the Focus Group

The strategy followed in this qualitative study was based on a semi-structured interview with 10 parents (N=10) of children between the ages of 0

TABLE I
OPERATIONALIZATION OF EACH CONFIDENT VARIABLE INTO CONCEPTS

Variable	Concepts related
Persistence	C1
Customization	C2, C14
Control	C3, C8,
Understanding	C4, C9, C12,
Privacy	C5, C7, C15, C18
Intimacy	C13, C15, C17
Safety (Security)	C6
Suitability	C10
Intuitiveness	C11
Transparency	C13
Reciprocity	C16
Resilience	C19
(Adaptability)	

and 6, grouped in two groups. This division allowed comparison of the results obtained with the purpose of determining the objectivity of the responses and their validity.

The interview was organized with an initial

presentation of a case study based on [58], a scenario that the group was to discuss for 15 minutes. After the discussion, participants were asked to individually select the 5 cards that best defined the subjective ideas that they had processed during the discussion. Subsequently each set of selected cards was presented to the rest of the members of the group and the selections were discussed. At the conclusion of the study, each member of the group, through a dialogue with the other members, had to associate each selected card with a pattern of interaction. Each pattern was presented to the group indicating its name and the problem it was designed to resolve as well as how it solves it.

The scenario presented at the beginning of the interview was defined as follows:

“The developed pervasive service offers the possibility to monitor the development process of children during their play activities. This service is oriented at constantly monitoring children's play activity, provided it is accessed, i.e. while it is operating. In this way, the professional supervision extends to unsupervised contexts such as the home.”

For this pilot study, we can imagine the following situation. We have a monitoring service that is going to be implemented in the home, specifically in each child's bedroom. This service monitors uses toys. Their appearance is identical to traditional toys but they include sensing and computing capabilities.

The service must be operational when the child is playing. Through interaction with each toy, it is possible to detect actions involved in the study of the user's psycho-motor development. In addition, the toy or set of toys must be able to be used in other situations where the service is not operational.”

D. Results of the Verification Process

The results were organized according to the selected cards for each subject, with a maximum of 5. These 5 cards represent the concepts of most importance according to each subject after having discussed them with the other members of the group. Each card gives a weight to a variable and each variable affects a particular problem, collected in each one of the patterns of interaction defined.

Once the cards were selected by the study subjects, they had to associate to each interaction pattern and each card only could be posed in one pattern. An example of the result of this process is presented in the Figure 1. Finally, Figure 2 graphically displays the distribution of the weight given by participants.

As it can be seen, the analyzed variables can be grouped according to the aspects that they affect in a IoT product, a pervasive sensitive service and their deployment into SSs. The variables related to the protection of information, represented with the color blue, are privacy, security and transparency. The variables shown in yellow are related to the acceptance requirements exposed as a first conceptual result of this research. Lastly, in green, the group of variables that refer to the nature of a pervasive and sensitive service that affect the correct deployment of the latter, i.e. the persistence of the service, the capacity of adaptation to user or customization and its suitability or utility. Figure 3 shows a Graphical representation of this votes distribution.

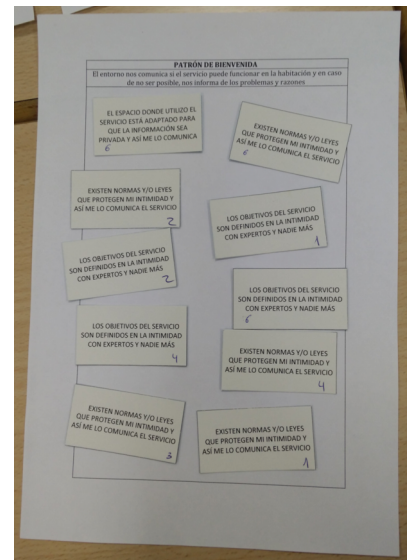


Fig. 1. Example (in Spanish) of the association of cards to Greeting Pattern carried out during the verification focus groups. Each card adds a point of weight to the patter associated.

V. DISCUSSION

The set of interaction patterns presented in this research work offers to designers and developers a guideline to design SSs where pervasive sensitive services have to be deployed in order to foster the final user acceptance. These interaction patterns are focused on encouraging a psychological state of

confidence on users, paying special attention to the understanding and control by the users on every relationship with the environment and therefore, the services deployed into it.

This approach supposes to involve final users in early stage of development of SSs and to include sociological and psychological issues (confidence) in the design of deployment of pervasive sensitive services. In addition, this research work continues with the idea pointed out in [60]. Here, authors postulated the emphasis of next step in computer science is the study of what humans can do rather than what computers can do, and therefore deals with all aspects of human psychology, which bring about technologies.

The analysis of the results shows that privacy and security and the associated feeling of intimacy play a crucial role in developing pervasive sensitive services and the environments where they are integrated. The associated variables collected a total of 23 votes, 40% of the selection. Intimacy represents the variable with the greatest weight for interviewees. Privacy and security, commonly understood as synonyms (and thus recorded by the subjects) are also key aspects in developing this type of services. In general, the results show that the patterns of interaction must meet the needs of users regarding the protection of their activities that are affected. To do this it is necessary that each one of the actions that the user takes are covered by regulations or laws.

The variables related to the requirements of acceptance and confidence-building represent 34% of the selections, with a total of 20 votes. In this set of variables, resilience obtained 0 votes out of a total of 10 possible. As analyzed from the discourse obtained during the pilot study, users did not contemplate the possibility of using the technology, smart toys, with a different purpose than the one offered by the service. However, this feature is very important when it comes to elements of interaction with children. Children represent a very variable target subject, whose behavior is unpredictable and therefore, developments must withstand different uses to those planned.

The remaining variables represent 26% of selections by the subjects interviewed. It should be noted that the score obtained by suitability, with 8 votes out of 10 possible, was the most important variable if it is analyzed independently. It is clear that for a service to be fully accepted, the results obtained when used must be the ones expected. For that to happen, the patterns of interaction must provide the necessary information so that the user has a record of its evolution, without being detrimental to the correct development of the service.

As shown in Figure 2 the results establish that confidence and management of the information and activity in a private and secure manner are the most important features for users. This means that the patterns must be able to provide a design solution

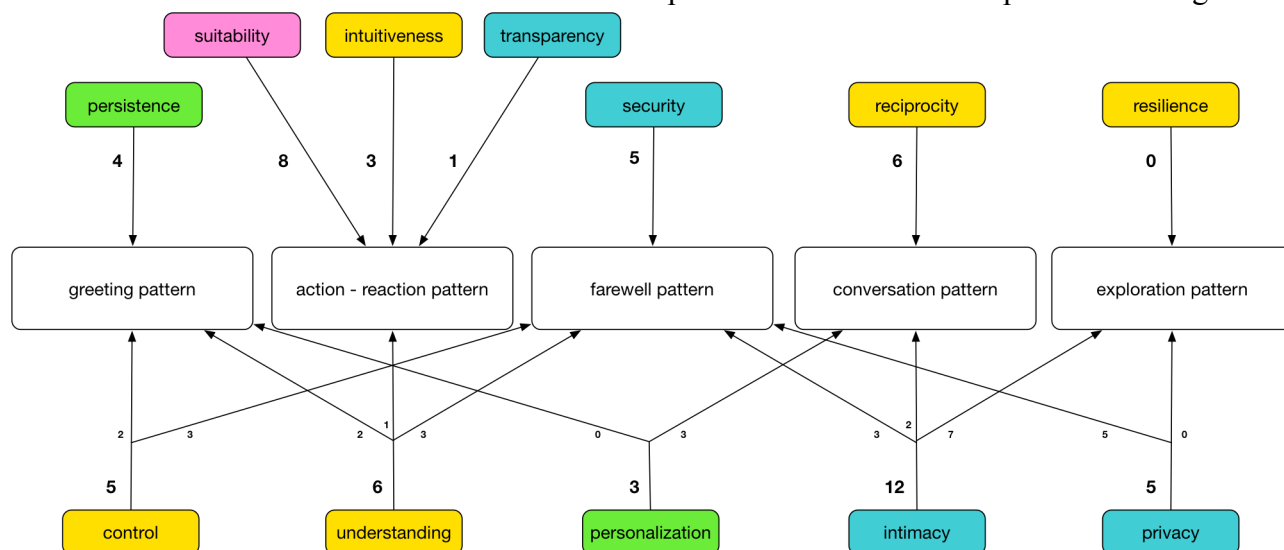


Fig. 2. Graphic representation of the distribution of the weight given by participants. The green cluster brings together the concepts related with pervasiveness, yellow is for confidence variable, blue for privacy and pink color for suitability.

that allows modelling the communication relationship between users and services deployed into the SS in two directions. They must promote a psychological state of confidence, through clear and precise dialogues, easily understood by the users, with the aim of providing control over the behavior of the system. In addition, they must ensure the protection of the information about users and their activities gathered during the use of the system, either through confident channels of dialogue or the involvement of trusted entities, such as doctors, installers, etc.

Thus, these patterns were presented to final users of SSs and they ranked them, following the marks presented in Figure 3. This process was conducted by an informal discussion where end users could judge and also opine about the patterns proposed. Once finished this discussion, users were asked whether another type of pattern was needed. All responses were aimed at improving the design patterns proposed since users concluded that these were adequate to cover the needs analyzed during the investigation. For IoT and services oriented to sensitive aspects such as presented in this paper, users were agreed with the feedback proposed but they suggested fewer messages in case of less intrusive and intimate applications.

Finally, in order to provide a full evaluation of the design patterns proposed is necessary to apply them in the development in larger scale real applications. The main challenge remaining for this research is to validate that indeed acceptance factors reflected during the design of SSs are truly transferred to

final development. This will make it possible to verify that the acceptance factors shaped by the patterns are actually perceived by users while using the services deployed in the SSs. To perform this, it is planned to use these patterns during the development of pervasive sensitive services to be deployed in several smart homes located in the organizations involved in this research.

VI. CONCLUSIONS

The emergence of persuasive technology and ubiquitous computing as a means of developing new services of the Information Society has increased the importance of intelligent environments. These environments, endowed with a certain degree of processing and communication capabilities, are used by these new services as an interface so that final users must interact with the environment to access to the functionalities of the services. At the same time, this new paradigm of services directly affects the daily life of the final users transforming the living spaces where they are immersed such as their homes, schools, hospitals, etc.

To improve the acceptance of this new paradigm, the new developments of SS have accepted a more personalized approach. This new approach set up services represent the intentions of the user and therefore the SSs must try to adapt to them, facilitating their deployment and operation. However, this change of approach is inadequate to ensure the acceptance of the SS when intimate services are deployed. It is imperative to include cognitive aspects to guarantee a proper adaptation to the users' expectations. These aspects must be addressed from the earliest stages of the development of such services and therefore this paper proposes a design and analysis tool aimed at this purpose.

The relations established with the user pervasive sensitive services and SSs where they are deployed can be modeled from the beginning using interaction patterns. This tool aims to facilitate the work of all those involved such as developers, vendors or integrators.

As seen during the work presented, these patterns directly consider important psychological and

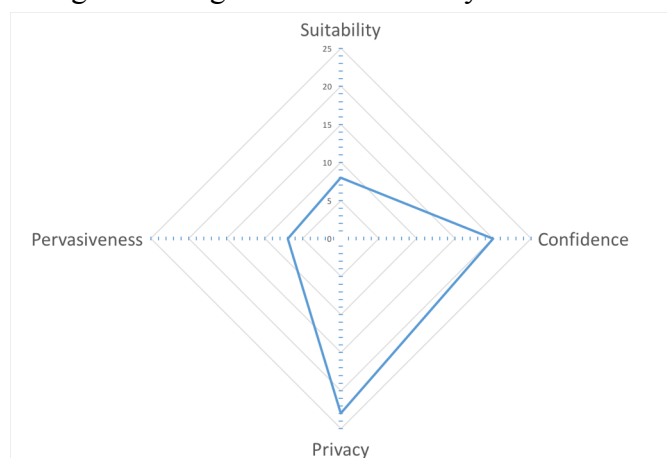


Fig. 3. Graphical representation of the distribution of votes for the operationalized variables corresponding to a pervasive sensitive service in an SS.

sociological aspects as understanding, control or intuitiveness, in order to ensure an optimal level of user confidence. This makes it possible to cover, from the initial stages of development, challenges and key variables to ensure complete acceptance of these complex solutions.

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